Modeling Needs for Very Large Systems

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Large Plants are Here, Larger Plants are Coming

Olmedilla-Park-Solar, Spain
60 MW

Waldpolenz Solar Park,
near Leipzig, Germany
40 MW (thin film)

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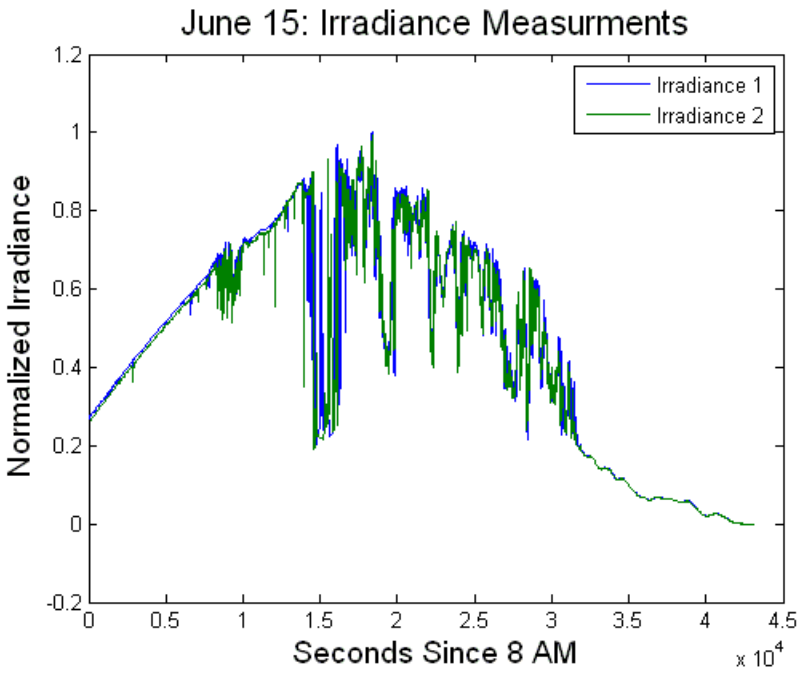
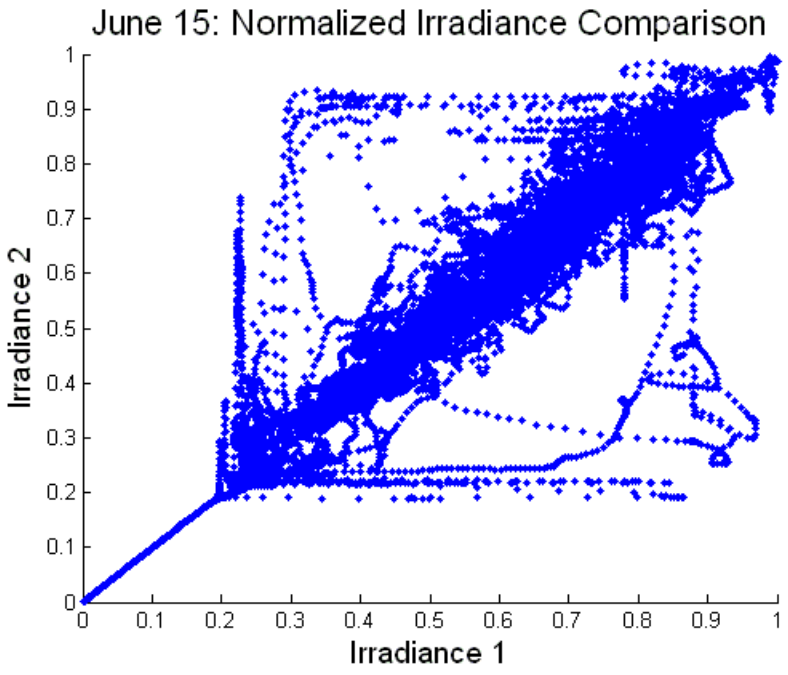
Goals and Objectives

- **Identify factors that need to be represented differently between large and small systems.**
  - Irradiance issues
  - Module Temperature issues
  - Reliability Issues
  - DC Loss Issues
  - Tracking issues
  - Inverter issues
- **Industry knows how to do this for their systems**
- **Customers/Financiers need independent validation of performance estimates**

Irradiance Issues

- **Irradiance measured at a point is not representative of the irradiance over the field**
  - Is this true for hourly averages?
  - How ‘micro’ are microclimates?





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Module Temperatures

- **Module temperatures fluctuate across a large array in a more complex way than for a small array**
  - Heat island effect?
- **Wind speed across the array can vary spatially**

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Reliability Issues

- **Josh's Rule #1: Something is always broken on a large PV system**
  - **Corollary**: O&M strategy is important for system performance
    - On-site technician?
    - Spares?
    - Monitoring system?
- **Monitoring at the inverter level fails to identify string failure when #of strings is large.**

• Le Chatelier's Principle (applied to Systematics): Complex systems tend to oppose their own proper function. As systems grow in complexity, they tend to oppose their stated function.
• The Fundamental Failure-Mode Theorem (F.F.T.): Complex systems usually operate in failure mode. A system can fail in an infinite number of ways.

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DC Loss Issues

- Large arrays by their very nature have much longer wire runs, more combiner boxes, more connectors, fuses, etc.
- Wiring losses are more important.

- Need to understand this relatively simple derate

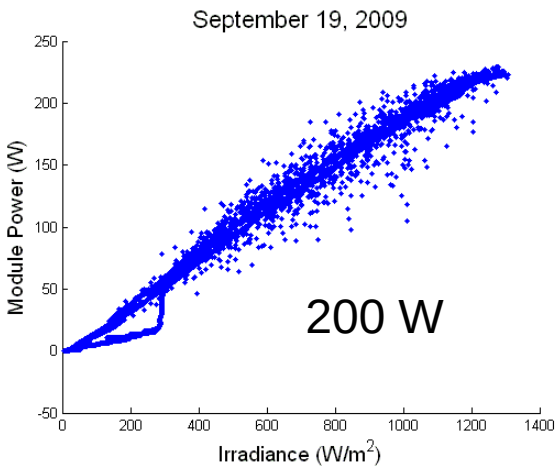
- Other derate issue: local topography and wind patterns can cause soiling to be uneven across the array (e.g., maybe one side of the array is near a road or agricultural field and gets more soiling)

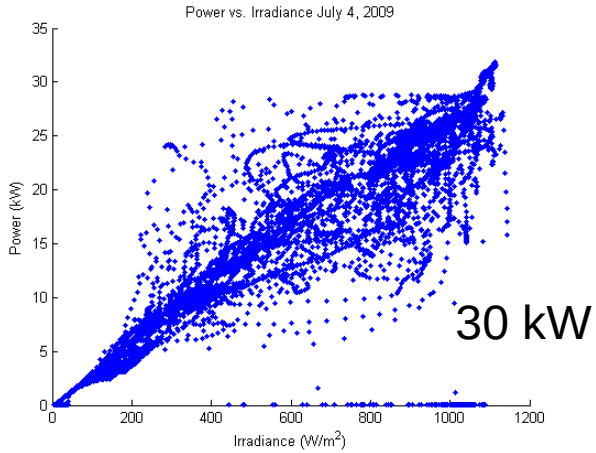
Tracking Issues

- **Large arrays are more likely to have trackers**
  - POA calculation is important!
- **Tracking errors, failures, etc. are much more likely to occur (see Josh's Rule #1)**
  - Result in complicated output profiles
  - Misalignment
  - Parasitic loads

Inverter Issues

- **Large arrays connected to large inverters routinely experience heterogeneous dynamic irradiance conditions (partial shade on array as clouds pass).**
- **MPPT performance will be different than for a small array, which is more homogeneous at any one time.**
  - This is an active area of research in industry but the results are not publically available.
- **Large systems may employ different inverter configurations (e.g., multiple inverters on DC bus)**





100 MW ???

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Conclusions

- **Existing models need to be validated for large systems and new models/submodels need to be developed and made accessible.**
- **Data from large PV systems is needed for model validation and improvement.**

- **Large integrators understand these issues the best, but are not always willing to share their specific knowledge.**

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